

DYNAMIC TESTING OF GASIFIER REFRACTORIES

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PROGRAM OBJECTIVE

Materials issues can often be a major hurdle in the advancement of new technologies. Refractory degradation under slagging gasifier conditions is one example. The University of North Dakota Department of Chemical engineering in partnership with the Energy & Environment Research Center is working towards a better understanding of this problem and an eventual solution for the same. The program aims to thoroughly examine the combined chemical (reaction and phase change) and physical (erosion) effects experienced by a variety of refractory materials during both normal operation and thermal cycling under slagging coal gasification conditions. The goal of this work is to devise a mechanism of refractory loss under these conditions.

ACCOMPLISHMENTS TO DATE

The Controlled Atmosphere Dynamic Corrodent Application Furnace (CADCAF) is being utilized for this work. The CADCAF is an electrically heated furnace capable of reaching temperatures of 1600°C. Slag samples are fed onto a refractory sample that is located in the heated chamber. The slag melts in a pool at the top of the brick, and slag runs down the side along a precut channel and eventually exits into a slag pot. The system is fed with a mix of 2% H₂ in a nitrogen base to ensure the system is reducing to iron. Slag is fed into the system for a prescribed time after which the refractory sample is removed and analyzed to determine the extent of degradation. The slag from the slag pot is also recovered and analyzed.

Testing to date has been performed using two slag samples from U.S. gasifiers. Slag A is characterized by a relatively high silica and alumina content (59%), 15.6% iron, 19% basic elements (Ca, Mg, Na, K), and 4.5% vanadium. Slag B has 48% silica and alumina, 44% iron, and 8% basic elements. The two refractory types tested to date are high alumina and a high chrome/alumina.

The alumina refractory showed evidence of dissolution when exposed to both Slag A and B. The slag collected in the slag pot with sample A showed an enrichment factor in alumina ranging from 1.5 to 1.7, indicating that the refractory brick was being dissolved by the slag. Slag A was a foaming slag and left a residual of slag on the brick after the test, making it difficult to qualitatively assess the extent of refractory loss. SEM analysis of a cross section of the brick is currently in progress. Slag B also caused significant refractory loss on the alumina brick. This was visibly noted after the test. Chemical analysis of the slag collected in the slag pot and of the refractory brick is currently in progress. Therefore no quantitative results are available for this slag/refractory combination.

The high chrome/alumina refractory showed a higher resistance to degradation than the alumina slags. There was very little visible wear from tests with either of the slags. Based on the analysis of the slag in the slag pot, it did not appear that any appreciable alumina was dissolved from the refractory samples. The increase in alumina in the slag pot catch was within experimental accuracy. However, chrome has an enrichment factor of 2, indicating that chrome may be selectively dissolved from the refractory. Detailed analysis is still in progress.

FUTURE WORK

Additional slag/refractory pairs will be run. Chemical analysis of the exposed refractory and the resulting slag will be performed to investigate, among others, chrome and alumina depletion, calcium and iron penetration, over all dissolution, depth of penetration by corrosion materials, and the total amount of refractory material lost. This information will be combined with physical observations to propose corrosion mechanisms.

LIST OF PUBLISHED JOURNALS ARTICLES, COMPLETED PRESENTATIONS AND STUDENTS RECEIVING SUPPORT FROM THE GRANT

Conference Presentations

- Shukla, D.; Mann, M.D., “Dynamic Testing of Gasifier Refractory”, presented at Graduate Studies: All Things to All People – Second Annual Scholarly Activities Forum, Grand Forks, ND, Feb 11, 2003.
- Shukla, D.; Mann, M.D., “Dynamic Testing of Gasifier Refractory”, presented at Living the Life of the Mind – Third Annual Scholarly Activities Forum, Grand Forks, ND, March 2-4, 2004.

Students Supported Under this Grant

- Xi Hong, graduate student, Department of Chemical Engineering, University of North Dakota.
- Devdutt Shukla, graduate student, Department of Chemical Engineering, University of North Dakota.
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